BULLETIN

OF THE

Society for the Promotion of Engineering Education

Vol. II LANCASTER, PA., APRIL, 1912 No. 8

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EDITORIALS.

The Annual Meeting.—Now that the Society has a monthly publication it is possible for the entire membership to participate in current discussion of topics which formerly had to be taken up at the annual meetings. The programs of the annual meetings can, therefore, be planned to accomplish their two primary functions; first, to permit the treatment of broad, general questions of importance and interest to all, and second, to enable the members to get acquainted with each other. The program this year is planned to accomplish these

two ends. President Raymond has worked out a general scheme and has placed the details of the several sessions in the hands of specialists in the matters to be covered. The local arrangements of the meeting are in the hands of a committee comprising Professors Allen, Anthony, Jackson, Marks, Tyler and Williston and Mr. Alexander.

The "Tech's" Good Fortune.—The announcement of a number of liberal gifts insuring the speedy completion of the required new buildings for the Massachusetts Institute of Technology on the recently acquired site has given general satisfaction. Certainly no institution has been confronted with more difficult problems than those which this great school has had to face in recent years. The apparently spontaneous good fortune comes as a reaction to the stress of the past few years.

Teaching Physics to Engineering Students.—Professors Franklin and MacNutt have outlined some new and startling ideas regarding science teaching. They depart from traditional lines in many respects. The authors have put their thoughts into graphic form for the purpose of stimulating discussion. They were requested to inject some "ginger" into the subject and they have done it. Contributions to the discussion of the two papers will be printed in the May BULLETIN if received promptly.

NEW MEMBERS.

The Council has elected the following list of applicants together with Messrs. Earle, Howlett, Schwarze, Smallwood and Sweeny, whose names are listed on page 356 of the March BULLETIN.

BLACKBURN, H. W., Instructor in Mechanical Engineering, University of Vermont, Burlington, Vt. 1912

DARGAN, F. T., Acting Professor of Electrical Engineering, Clemson A. & M. College, Clemson College, S. C. 1912

DAVIS, R. P., Associate Professor of Structural and Hydraulic Engineering, West Virginia University, Morgantown, W. Va. . 1912

GREVE, F. W., JR., Instructor in Hydraulic Engineering, Purdue University, Lafayette, Ind. 1912
HOLMAN, W. F., Instructor in Mathematics, University of Minnesota, Minneapolis, Minn. 1912
LANE, A. C., Pearson Professor of Geology and Mineralogy, Tufts College, Tufts College, Mass. 1912
LEKBERG, C. H., Instructor in Mechanical Laboratory, University of Maine, Orono, Me. 1912
MCCLELLAND, E. H., Technology Librarian, Carnegie Library of Pittsburgh, Pittsburgh, Pa. 1912
MARIS, J. M., Principal, School of Structural Engineering, International Correspondence Schools, Scranton, Pa. 1912
ROLLINS, A. P., Assistant Engineer, Medina Irrigation Co., San Antonio, Texas 1912
TRAILL, J. J., Lecturer in Hydraulics, University of Toronto, Toronto, Ont., Canada 1912
WICKENDEN, WM. E., Assistant Professor of Electrical Engineering, Massachusetts Institute of Technology, Boston, Mass. .. 1912

APPLICANTS FOR ADMISSION.

BARK, ELMER, Instructor in Mechanical Engineering, University of Pennsylvania, Philadelphia, Pa. 1912
BOYER, E. E., Electrical Superintendent, General Electric Co., Lynn, Mass. 1912
BROWN, CHAS. B., Professor of Railroad Engineering, University of Maine, Orono, Me. 1912
BRYDEN, CHAS. L., Principal of School of Metal Mining and Metallurgy, International Correspondence Schools, Scranton, Pa. .. 1912
EINSWILER, J. E., Assistant Professor of Mechanical Engineering, University of Michigan, Ann Arbor, Mich. 1912
FULTON, WM. L., Assistant Professor of Mathematics and Civil Engineering, University of Vermont, Burlington, Vt. 1912
HANDFORTH, C. H., Instructor of Mechanical Drawing, Wentworth Institute, Boston, Mass. 1912
MICKEY, C. E., Adjunct Professor of Applied Mechanics and Machine Design, University of Nebraska, Lincoln, Nebr. 1912
MOODY, L. F., Assistant Professor of Mechanical Engineering, Rensselaer Polytechnic Institute, Troy, N. Y. 1912
PASSANO, L. M., Assistant Professor of Mathematics, Massachusetts Institute of Technology, Boston, Mass. 1912
PORTER, CHAS. T., Instructor in Mechanical Engineering, Sheffield Scientific School, Yale University, New Haven, Conn 1912
PROCTER, J. H., Instructor in Electrical Engineering, Texas A. & M. College, College Station, Texas 1912

THOMAS, CHAS. W., Instructor in Mechanical Drawing, University of Wisconsin, Madison, Wis. 1912
WYMAN, F. T., Chief Electrical Engineer, Pittsburgh Transformer Co., Pittsburgh, Pa. 1912

THE BOSTON MEETING.

The preparations for the Boston meeting are going forward rapidly and there is every prospect of a profitable and interesting gathering. President Raymond's plan of holding a number of sessions devoted to section meetings at which the problems connected with laboratory administration will be discussed has met with general approval. The educators who will have charge of the different sections, as arranged to date, are as follows: On Mining Laboratories, Prof. F. W. Sperr, Michigan College of Mines; on Mechanical Laboratories and Shops, Prof. A. M. Greene, Jr., Rensselaer Polytechnic; on Electrical Laboratories, Prof. J. O. Phelon, Worcester Polytechnic Institute; on Materials and Hydraulics Laboratories, Prof. F. J. McKibben, Lehigh University.

Brief announcement of other features of the meeting were published in the March BULLETIN. A more complete account with details of the plans arranged for the different sessions by those in charge of them will be made in the May BULLETIN.

The Program Committee announces that the meeting will be held one day later than originally announced in order that there may be less conflict between the sessions of the American Institute of Electrical Engineers Conventions and those of the Society meeting. Our meeting will begin on Wednesday, June 26, continuing possibly to Saturday morning.

LETTERS TO THE EDITOR.

EDITOR S. P. E. E. BULLETIN,

Dear Sir: The readers of the BULLETIN will be interested in the report recently made by Dean Shenehon, of the College of Engineering, University of Minnesota, on "The Preservation of Niagara Falls." This report was made to Major Chas.

Keller, of the United States Engineer Corps, and it has been published as Senate Document No. 105. The report contains sixteen chapters of scientific data, accompanied by interesting discussion and interpretation. It is illustrated by an extensive series of elaborate maps and photographs. General W. L. Marshall, Chief of Engineers of the U. S. Army says of this report: "The investigations were commenced in 1906, continued in 1907 and 1908, and have been of a most thorough and searching character, and Major Keller and his assistants are entitled to great credit for their execution of this complex, difficult and dangerous work." In closing his report Dean Shenehon makes a unique suggestion as follows: "The Falls are operative only as a scenic spectacle during the daylight hours. When night sets in partial depletion would not be scenically injurious. Should permits be issued for half the flow of the river from sunset to sunrise, or for 12 or 16 hours every day, a tremendous power would become available that would furnish its own light, and factories might work by night instead of by day. The temporary lowering of the river would immediately adjust itself when the sunrise shut-down came. The interference with night navigation on the river would not be prohibitive in view of the benefits to be conferred in cheap power and light. The use of night power at Niagara implies the regulation of Lake Erie's outflow." The author suggests the construction of proper works to accomplish such regulation, thus so impounding the waters of the lake as to make it a reservoir.

Very truly yours,
ARTHUR E. HAYNES.

EDITOR S. P. E. E. BULLETIN,

Dear Sir: I wish to suggest that if the Society would furnish its members with a certificate of some sort it would increase the interest in the Society and would serve as a tangible bond among the members. Other engineering and educational societies do this and I am sure that our members would not object to paying a reasonable price for such a certificate. I

should like to have opinions on this matter through the columns of the BULLETIN.

Very truly yours,
RUSSELL R. UX.

SECRETARY S. P. E. E.,

Dear Sir: Apropos of Principal Williston's article in the December number of the BULLETIN the following may be of value.

The first building of the Ranken School, erected in 1908, was planned after a careful study of existing schools but necessarily with no means of forecasting at all definitely either the physical or the educational development of the institution. The building has in many ways proved itself admirably adapted to certain phases of our work. The fact, however, that all the interior partitions (see the accompanying typical floor plan)* are solid bearing walls of brick has prevented us from making certain alterations, such as changing the arrangement of store rooms and shops and enlarging certain rooms and making others smaller, that have from time to time seemed desirable. This fact has led us, in the interest of an economical distribution of space as the needs of the several departments vary, to an adaptation of Mr. Williston's scheme in the planning of all future extensions. The typical floor plan of the building now under way is 76 ft. wide instead of 48 ft. This happens because the central portion is designed for our administration building and contains the power plant and administrative offices on the first two floors and on the third floor the drafting rooms lighted from the sky. In the wings, however, we have come down to the 48 ft. width, and in the accompanying block plan you will note that we expect to adhere rather closely to Mr. Williston's scheme.

The 48 ft. width suggested by Mr. Williston lends itself, we believe, to the desired flexibility by allowing rooms of convenient size on either side of the corridor, where a corridor is desirable, and at the same time, where a larger floor space

is desirable, gives a large single room not too wide for adequate lighting.

By using four-inch hollow tile for partitions and depending upon the columns alone for the support of the floors and roof, we figure that we can make a building which we can remodel internally at any time just as the modern office building is remodeled to suit the needs or the convenience of the individual tenants.

A further advantage of this unit form of construction is that the school can develop physically pretty much like the game of dominoes, by the addition of a smaller or a larger block of construction at any time. Our next move after this new building is completed will doubtless be to prolong the main front by the addition of the two extensions marked A and B on the block plan.*

Very truly yours,

LEWIS GUSTAFSON,

Superintendent.

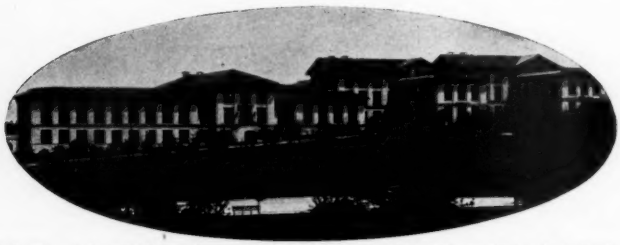
* References are to figures included with the description of the Ranken School, p. 422.

THE NEW BUILDINGS OF THE CARNEGIE TECHNICAL SCHOOLS.*

BY A. W. TARBELL,

Registrar of the Schools.

In giving Pittsburgh the Institute which bears his name, Mr. Carnegie had for a purpose the creating of an educational institution which would serve the intellectual welfare of the city as his steel works have served her material welfare. The Institute is divided into three departments, the Fine Arts, the Museum, and the Technical Schools. The first two, with the Carnegie Library, are housed in the Institute building, while the schools occupy eight buildings of their own upon an



Schools of Applied Design and Applied Industries (from Schenley Park).

adjoining site of 32 acres. About one fourth of the proposed building programme of the schools has been completed, the structures being placed so as to ultimately form a large quadrangle with a terraced campus in the center.

The founder's original gift, made in 1905, was one million

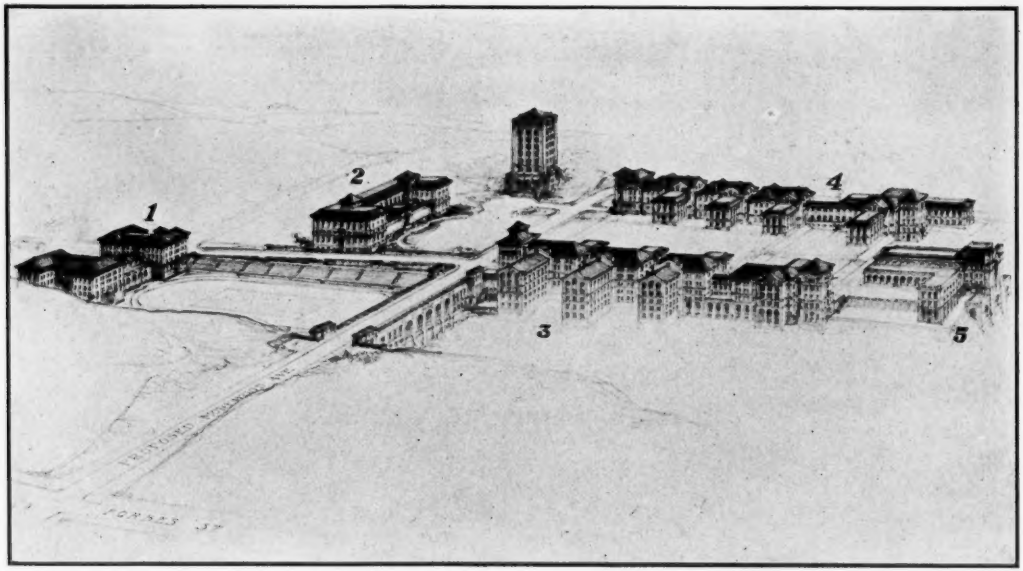
* As this goes to press, the Board of Trustees has voted to change the name of the Carnegie Technical Schools to the Carnegie Institute of Technology, and the necessary steps are now being taken for incorporation with the power to grant degrees.

dollars, but the demand for instruction having been such as to make frequent extensions necessary, Mr. Carnegie, has, in consequence, increased his benefactions from time to time until they now total four million dollars for buildings and equipment, and seven million dollars for endowment.

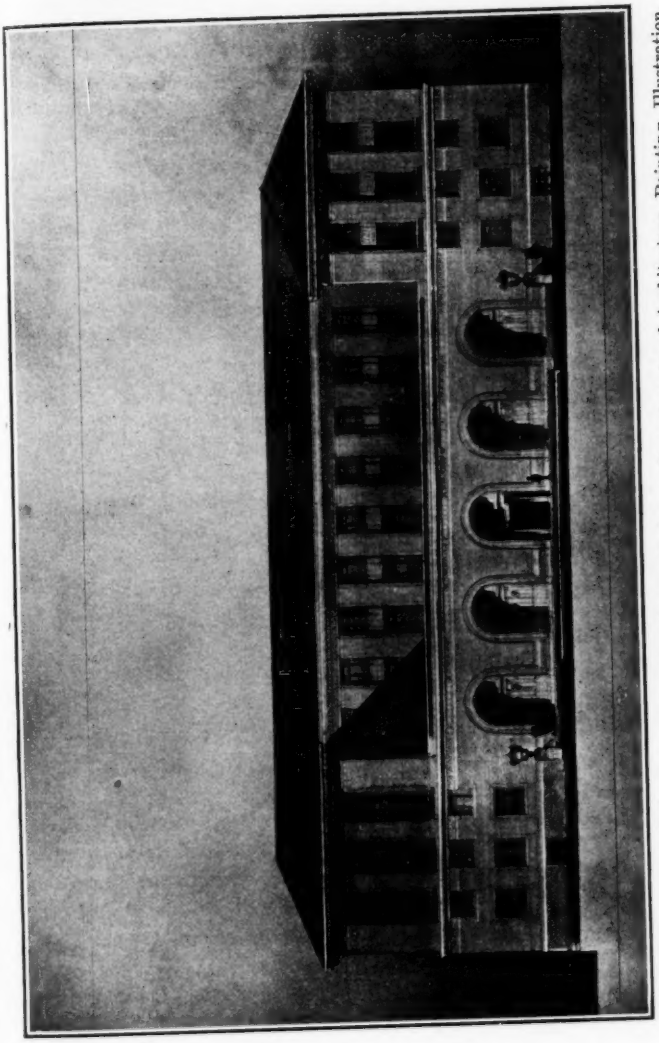
As a result of his most recent gift of one and a half million dollars several new buildings are about to be erected. These will include two new buildings for the School of Applied Science, one for the School of Applied Design, and one for the Margaret Morrison Carnegie School for women. After these enlargements are completed facilities will be available for 3,000 students, or six hundred more than the present registration.

Of the two new buildings for the School of Applied Science, one will be a head house for the group of engineering buildings. It will contain no laboratories, the plans calling for lecture and class rooms, an auditorium, an engineering museum and administration offices. The second building, for the exclusive use of the Civil Engineering Department, will be a four-story structure, 60×175, which will provide space for a large double-story hydraulic laboratory, a testing laboratory of equal size, drafting rooms, class and instrument rooms, and several small laboratories.

The work of preparing the site for the new School of Applied Design building has been completed, and foundations were started last month. Its location will be imposing, as it is to stand at the head of the campus and will be approached through a large open court. The dimensions are to be 260 feet long by 110 feet wide, and the structure will house the departments of architecture, painting, sculpture, illustration, interior decoration, music and the drama. There will be three stories, a mezzanine and a high basement. The first floor will contain an auditorium, elliptical in shape, for lectures, plays, concerts, etc., with a seating capacity of 500. It will also contain a working museum and an art gallery for the permanent exhibition of student work. The second and third floors will be devoted to drafting rooms, laboratories, class rooms and ateliers. The studios will be at the top of the building with



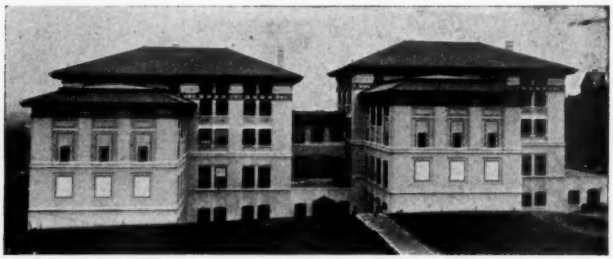
Bird's-eye View of Completed Project. (1) School for Women, built and in use. (2) School of Applied Design, under construction. (3) School of Applied Science, part completed and in use. (4) School of Applied Industries, in large part completed and in use. (5) School of Applied Science, one story completed and in use (for laboratory purposes). Note projected entrance from Forbes Street over roof of gymnasium.



School of Applied Design (under construction). To house Departments of Architecture, Painting, Illustration, Interior Decoration, Sculpture, etc.

all light coming from the north. The basement will contain, besides the usual arrangements for janitor and storage, a large modeling atelier twenty-five by one hundred feet, designed in Florentine style.

Another new extension under way is the engineering camp. The founder recently presented the schools with the use of a 750-acre farm situated at Garver's Ferry, twenty miles from Pittsburgh. At the same time he made a gift of the funds necessary to convert the farm into an engineering camp. The property has a water frontage of one and a half miles on the Allegheny River, and the topography of the land is such as to provide suitable practice ground for the students in the civil engineering department, who will be stationed here at certain periods of the year for all their practical work. Three streams and two coal mines, located within the boundaries, are to be utilized for instructional purposes in hydraulics and

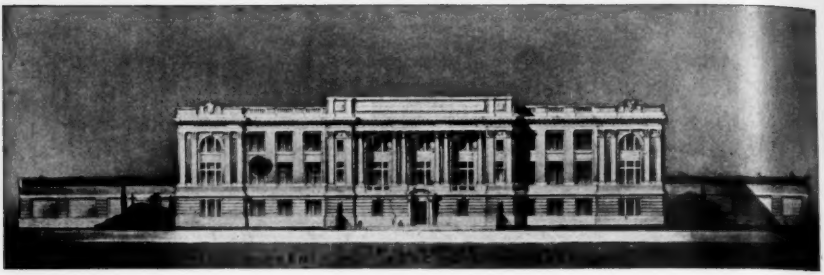


School of Applied Science.

mining engineering. The large old-fashioned mansion house on the property is being altered into suitable quarters for the accommodation of faculty and students during such times as they may spend at the camp. There will be offices, lecture and drafting rooms, kitchens, sleeping chambers and a "commons."

Under the name "Carnegie Technical Schools" are included four separate schools each with its own faculty and student enrollment. The types of education offered in these four

schools differ widely, a fact which has caused considerable confusion in the minds of the public as to the aim of the schools. The School of Applied Science offers courses in the different branches of engineering, requirements for admission including a certificate of graduation from an approved high school or its equivalent, and in addition examinations in certain fundamental subjects. The School of Applied Design, which is of about the same scholastic pitch, offers courses in architecture, painting, interior decoration and illustration. The School of Applied Industries provides industrial courses designed to meet the demand for men efficient in the machinery and building trades, and for the training of manual training and trade school teachers. The Margaret Morrison Carnegie School for Women trains students in the home-making arts, and to become teachers in the professions and industries as well as to be selfsustaining should economic conditions place them without the environment of the home.



THE DAVID RANKEN, JR., SCHOOL OF MECHANICAL TRADES.*

BY LEWIS GUSTAFSON,

Superintendent of the School.

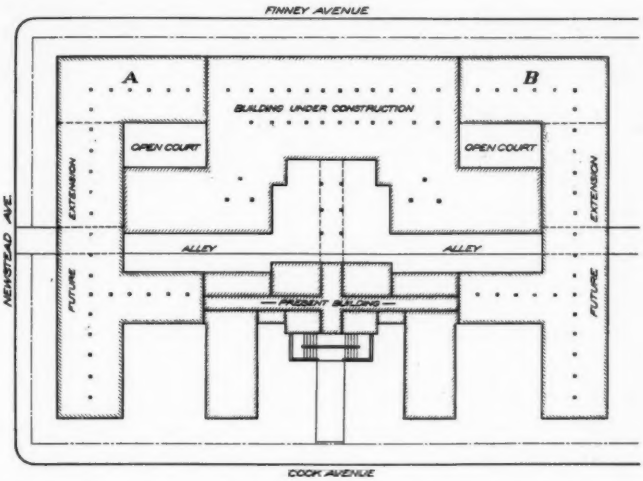
The David Ranken, Jr., School of Mechanical Trades of St. Louis owes its existence to the generosity of the late David Ranken, Jr., of that city. It was the carrying out of a long-cherished plan of Mr. Ranken to endow "an institution in the city of St. Louis and the state of Missouri for the purpose of training and fitting boys and men for the mechanical and manual trades and occupations, having in mind the need of the community and state for practical workers in mechanical trades who shall be skilled in their respective trades and occupations, and have such education as will best fit them to serve the community and the state in such occupations."

The work of the institution may be separated into three divisions: the day school, the evening school, and the coöperative course.

The day school opened its doors for the first time in September, 1909, and is therefore in its third year. The trades selected for instruction are carpentry, bricklaying, plumbing, sign painting, decorating, steam engineering, and pattern making. Two-year courses in these subjects, open to boys of fifteen and over, who have finished six grades in the schools, or their equivalent, have been planned in such a way as to

* See also Mr. Gustafson's letter on p. 414 of this issue.

give students a large amount of practical shop work, together with a careful training in drafting, applied science, and applied mathematics. The idea is to make practical mechanics who shall know how to read plans, make calculations, and understand the general principles underlying their work. The instructors are all men of successful trade experience. The tuition fee is thirty dollars a year with all tools and

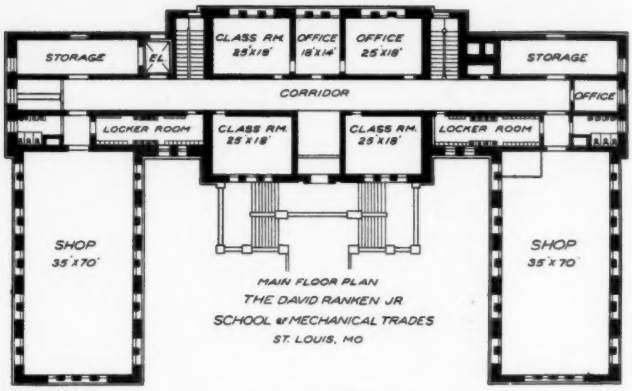


Block Plan—The David Ranken, Jr., School of Mechanical Trades.

materials supplied by the school, the students supplying such small incidental items as drafting instruments, overalls, pencils, and the like.

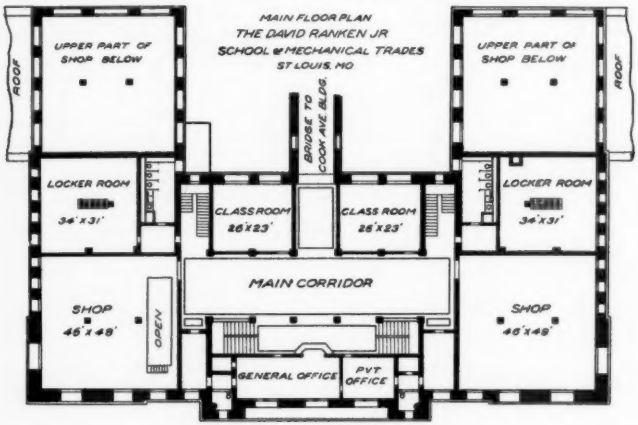
Evening classes in plumbing, painting, bricklaying, carpentry, applied electricity, and pattern making, with machine and architectural drafting, plan reading, and machine shop mathematics continue for twenty-four weeks each year.

In connection with the day school is carried on a course for machine shop apprentices in coöperation with the St. Louis branch of the National Metal Trades Association. The ap-



Cook Avenue Building.

prentices of the association come to the school two mornings in the week for instruction in drafting, shop mathematics, and applied science, the employers paying the apprentices for their time and paying the tuition fee of fifteen dollars a year.



Finney Avenue Building.

The growth of the school since its opening has been very gratifying. The total enrollment for the first year was two hundred forty-seven, seventy-nine of these being of the regular day classes, one hundred thirty-six of the evening classes, and thirty-two of the coöperative classes. In the second year closing July, 1911, the day school enrollment increased to one hundred fifty-nine, that of the evening school to two hundred forty-eight, and that of the coöperative students to fifty-eight, making a total of four hundred sixty-five. Eighteen students, constituting the first class, were graduated July 21, 1911.

This year the enrollment has increased to such an extent that the present building is inadequate and a new building is now under construction. It is the intention, when this new building is completed in January, 1913, to include instruction in the machinist's and electrician's trades, to lower the minimum entrance age to fourteen years, and to lengthen the course to two and one half years.

THE GRADUATE APPRENTICE COURSE OF THE WESTERN ELECTRIC COMPANY.

BY J. W. DIETZ,

Manager of the Educational Department.

We often hear of the achievements and successes of a college man who is doing his share of the world's work. We are so interested in what he is doing now, that we rarely stop to think of how he got his start'' after he left the college. Helping college men to take up their chosen work intelligently, promptly and in an organized way is receiving considerable attention. Many graduates with technical training rightly attach much importance to such opportunities as are offered them to take up their new duties efficiently.

The Western Electric Company offers at its Hawthorne works, Chicago, three courses for college men, which lead to work in the engineering, manufacturing and commercial sides of the business. A synopsis of each of these courses is given below.

Engineering Course—52 Weeks.

This course is planned as a foundation for the company's engineering work and to give an insight into the use and service requirements for Western Electric apparatus and switchboards as they form a part of telephone exchange systems. By actual work and study, the student becomes familiar also with manufacturing methods, facilities and materials. The regular work in the departments listed below is supplemented by assigned reading, lectures, reports, quizzes, conferences and inspection trips.

1 Week—General.

History of the telephone; review of the telephone industry; the Western Electric Co., its history and organization; the

Hawthorne plant. Lectures, assigned readings and inspection trips.

15 WEEKS—CENTRAL OFFICE EQUIPMENT.

1 week—Metal and wood work for switchboard sections, cable racks, apparatus frames and power switchboards.

4 weeks—Forming and preparing switchboard cable for use in telephone exchanges; testing and inspection methods; cable plans for telephone exchanges.

10 weeks—Telephone switchboard wiring, testing and inspection, making cables for switchboard sections and mounting the necessary apparatus, studies of different types of principal sections manufactured.

5 WEEKS—CENTRAL OFFICE APPARATUS.

2 weeks—Study of principal types of apparatus used in telephone central offices, such as relays, keys, jacks, condensers, plugs and repeating coils. Study of service requirements and catalogue information. Actual assembly work in shop departments.

1 week—Setting up, testing and clearing trouble on typical subscribers' and trunking circuits. Use of testing apparatus, locating and clearing faults. Supplemented by visits to typical operating exchanges of the Chicago Telephone Company.

2 weeks—Study of manufacture of cords and switchboard and lead-covered cables for aerial, underground and submarine work. Raw materials, assembling, testing and inspection methods.

3 WEEKS—SUBSCRIBERS' STATION EQUIPMENT.

3 weeks—Studying and assembling of telephone subscribers' equipment for various types of service, also associated coin collectors and protective devices, and transmission standards. The manufacture of types of loading coils, touching also various classes of line construction.

18 WEEKS—CENTRAL OFFICE INSTALLATION.

Assignment to work at a telephone exchange in process of installation, where switchboards are being assembled, where circuits are being installed and tested and prepared for service. Power plant and storage battery installation and testing. Study of installation department methods.

8 WEEKS—EQUIPMENT DRAUGHTING.

Various practices and general designs and types of equipment. Information required by draughtsmen from engineers. Reasons for designs of apparatus and equipment; telephone exchange plans.

2 WEEKS—VACATION.

MANUFACTURING COURSE—52 WEEKS.

This course is planned to give a training in the fundamentals of shop management, methods and facilities, knowledge of the company's products, interchangeability of parts, properties of materials, quality and use of finished products. Actual shop and office experience in the regular departments listed below is supplemented by assigned reading, lectures, quizzes, conferences and inspection trips. The shop work and the related study give a broad insight in the company's manufacturing and its relations to other branches of the business.

1 WEEK—GENERAL (SAME AS IN ENGINEERING COURSE).

27 WEEKS—MANUFACTURING AND SHOP MANAGEMENT.

11 weeks—Issuing of shop orders, ordering raw materials, scheduling detailed piece parts for apparatus. Study of shop stock room systems. Tracing detailed parts, assembled apparatus and complete switchboards through the various manufacturing departments.

4 weeks—Assembling principal types of apparatus, such as subscribers' sets, relays, keys, condensers, repeating and loading coils.

6 weeks—In various machine departments, such as automatic screw machine, drilling, milling, metal finishing and punch press, to familiarize with drawing of stock, drawing of tools, setting up of machines, operating of machines, delivery of work, care of tools, inspection, counting and manufacture of detailed interchangeable parts.

4 weeks—In master mechanics' department to gain a general knowledge of the manufacture of tools.

2 weeks—Study of manufacture of cords, switchboard and lead-covered cable for aerial, underground and submarine work. Raw materials, assembling, testing and inspection methods.

5 Weeks—Central Office Equipment.

1 week—Metal and wood work for switchboard sections, cable racks, apparatus frames and power switchboards.

1 week—Forming and preparing switchboard cable for use in telephone exchanges; testing and inspection methods.

3 weeks—Telephone switchboard wiring, testing and inspection. Making cables for switchboard sections and mounting the necessary apparatus on different types of principal sections manufactured.

2 Weeks—Inspection Methods.

Organization and methods used by chief inspector's office, showing how work is carried on to insure quality; meeting specified requirements; investigation of errors and complaints.

15 Weeks—Central Office Installation.

Assignment to work at a telephone exchange in process of installation where switchboards are being assembled, where circuits are being installed and tested and prepared for service. Power plant and storage battery installation and testing. Study of installation department methods.

2 Weeks—Vacation.

COMMERCIAL COURSE—67 WEEKS.

This course is planned to give a broad training in warehousing, distribution, selling and business methods, which will prove of value to the man in the company's commercial work. Men on this course study the company's products and supply materials handled. They learn also regarding manufacturing methods and facilities. Through the entire course the regular departmental work listed below is supplemented by a schedule of lectures, assigned reading, quizzes, conferences and inspection trips.

1 WEEK—GENERAL (SAME AS ENGINEERING COURSE).

16 WEEKS—APPARATUS AND SUPPLIES.

8 weeks—In apparatus stock rooms.

8 weeks—In supply stock rooms. Handling apparatus to gain knowledge of the company's products and electrical supplies handled. Warehousing methods, packing, storing, filling and shipping orders.

16 WEEKS—MANUFACTURING DEPARTMENT METHODS.

4 weeks—Following orders and schedules for detailed parts of apparatus. Study of clerical and production methods. Manufacturing facilities, handling of raw material, testing and inspection.

6 weeks—Similar to the foregoing, except that completed apparatus is followed. Gives insight into facilities for assembling apparatus in large quantities; precautions for ensuring quality.

4 weeks—Similar to the foregoing, except that various telephone switchboard units are followed.

2 weeks—Following orders for cords, switchboard and lead-covered aerial and underground cables. Manufacturing methods, facilities, raw material, testing, inspection and shipping arrangements.

32 WEEKS—GENERAL SALES DEPARTMENT METHODS.

16 weeks—Handling sales orders and conducting correspondence with distributing houses and manufacturing departments.

16 weeks—Billing of apparatus and switchboard orders. Bookkeeping and accounting methods; pricing materials; handling of customers' and distributing house claims.

2 WEEKS—VACATION.

KEEPING INSTRUCTION OUT OF A RUT.*

BY DEAN J. H. LEETE,
Carnegie Technical Schools.

As an abstract proposition, all teachers recognize the desirability, if not the necessity, of keeping abreast of the latest developments of the subjects they are teaching. In engineering courses, it is further appreciated that it is especially important that the instructor keep in touch with the advances in the application of the theoretical principles of his subject to engineering practice.

The very fact that the same courses must be given year after year to students who have reached approximately the same stage of development, a fact which makes it possible each year to better the method of presentation, carries with it the danger to the instructor of wearing a rut which becomes deeper and deeper until it reaches the stage when it would take a derrick to raise the course to level ground on which it is free to turn to meet changing conditions. Moreover, under such conditions, the instructor himself loses touch with those outside interests and affairs which might be made most helpful to his course and serve to keep it a live subject in the curriculum. I recall, in my own college days, one course in particular in which the instructor had been telling the same story at exactly the same point for twenty years or more—indeed, the second-hand text books in use by some of us were so marked that we knew just what to expect. Probably there is no member of the Society who does not recall similar experiences and while we might be slow to recognize the same

* *Editor's Note.*—Dean Leete has written me that as a preliminary to the formal presentation of the plan described in this article to the Society he would be glad to receive word from those members of the Society who approve of the general idea proposed.

decadence in our own work, it is not improbable that the same conditions are producing a similar result.

Moreover, whether or not we recognize the truth of the above statement, it is undeniable that the student often fails to grasp the important bearing of certain subjects upon the attainment of the goal he has in mind, or, if he recognizes its importance, fails to recognize the identity between teaching and practice. The professional teacher has, rightly or wrongly, come to be regarded by the general public as unpractical and the student is too ready to adopt this viewpoint, both of his instructor and of courses of instruction. I am not advocating that all subjects should be taught from the bread-and-butter standpoint, for I believe far otherwise, but simply state that it is unwise not to make use of the additional stimulus to work which comes with the appreciation upon the part of the student that what he is getting is what he must know in his chosen field of work and that men in practice are drawing directly upon their knowledge of subjects he is now pursuing.

Engineering schools are, at present, employing some means of attaining this end. The requirement of summer work by students under industrial conditions, the encouragement of outside practice upon the part of members of the faculty, the frequent inspection visits to industrial plants, are all practiced by this school and have all proved helpful aids to our courses of instruction.

It has occurred to me, however, that there is another factor in producing the best atmosphere and conditions for engineering teaching which has as yet been but little used in our field, though it has achieved excellent results in the study of architecture. I refer to the enlistment of the engineering societies in our problem of educating engineers by a plan similar to that employed by the New York Society of Beaux-Arts Architects. This society holds annually twenty-five competitions for the study of architecture and ten for the study of archæology which are entered by about a dozen schools of architecture. Their committee on education sets the problems, fixes the time

to be allowed for their solution and passes judgment upon the designs submitted, the best drawings being published by the *American Architect*. The system has been carefully worked out, and is more elaborate than would probably prove advisable in the case of engineering work. The schools entering these competitions follow the plan to different extents. In our School of Applied Design students are required to obtain a certain number of values from these competitions to be eligible for graduation and from my own observation, I can state that the influence exerted by these problems set and judged by practicing architects, and the element of competition with other schools introduced thereby, have been extremely valuable to both faculty and students.

A year ago, we attempted to interest some of the national engineering societies in the problem with but indifferent results—due probably to the fact that the request came from but a single institution which was itself but a fledgling. We did succeed, however, to the extent of securing a problem in machine design, which was judged by outside engineers, an account of which may be found in the *Engineering News* for October 26, 1911. The results obtained in this very limited trial of the plan confirmed our ideas of its value to students and faculty. My hope in writing this article is that other institutions may be interested in the proposition and that the Society for the Promotion of Engineering Education may appoint a committee to formulate a definite plan, more simple and less extensive than that of the Beaux-Arts Architects, which may introduce these factors of coöperation by practicing engineers and of open competition in some selected courses of engineering instruction. The plan has the further advantages of transforming the teacher from the position of task-master to that of coach and has as a by-product a tendency toward the partial standardization of courses of instruction.

Just what form and to what extent the plan would prove helpful would require careful consideration and well-informed judgment. It would probably be wise to begin in a modest

way with a few subjects, limiting the competition to members of senior classes. If each national engineering society would each semester set three short problems requiring from three to six hours for solution and one more extended problem in design, I am confident that a very desirable and important stimulus would be added to our technical courses. The encouragement and fostering of technical education is surely a function of the engineering societies.

CIVIL ENGINEERING.*

The Scope of Engineering.

Tredgold's definition of civil engineering is usually quoted in abbreviated form. When thus given it is entirely too broad to apply to present conditions, but when stated as incorporated in the charter of the Institution of Civil Engineers in 1828 it has far more definite meaning, namely: that civil engineering is "the art of directing the great sources of power in nature for the use and convenience of man, as the means of production and of traffic in states both for external and internal trade, as applied in the construction of roads, bridges, aqueducts, canals, river navigation and docks for internal intercourse and exchange, and in the construction of ports, harbors, moles, breakwaters and lighthouses, and in the art of navigation by artificial power for the purpose of commerce, and in the construction and adaptation of machinery and in the drainage of cities and towns." This omits the economic factor which is so vital to most engineering projects. A definition more in keeping with modern commercial development is as follows: Engineering is the application of science and art to the conception, design, construction, and operation of works which utilize the great forces of nature in the production of wealth, and which accomplishes this with the least expenditure of time and energy. Civil engineering is that branch of engineering which has to do with certain classes of these works as shall appear later.

Engineers have been employed from the earliest times in construction of engines of offense and structures of defence,

* A portion of a paper read before the instructing corps of Lehigh University, February 9, 1912, by Frank P. McKibben. The omitted portion of the paper deals with the course of study in civil engineering at Lehigh University.

and even in the thirteenth century a "chief engineer" had at his command an organized corps of skilled workmen. At the seige of Calais in 1347 this body included builders, such as masons and carpenters, as well as armorers and gunners. It was not until the eighteenth century, however, that the term civil engineer was used to distinguish that group of civilians who, though sometimes engaged in constructing works of a character similar to those built by military engineers, had no connection whatever with military organizations. Leonardo da Vinci was a civilian who at times applied his energy in constructing engineering works both for peace and war. It is not generally known that besides painting, music and sculpture, Leonardo da Vinci reckoned the art of building engineering works among his accomplishments. In his letter to Ludovico il Moro, Duke of Milan, near the end of the fifteenth century, he lays great emphasis on his ability to construct bridges, implements of war and canals, and states furthermore that he is skilled in the architecture of public and private buildings. He built the canal of the Martesana by which he brought the Adda to the walls of Milan, an engineering feat of no small proportions. Among his writings is a treatise on hydraulics. He was greatly interested in natural sciences and, in an age of so much dogmatism, first laid down the principle of Bacon that experiment and observation must be guides to theory in the investigation of nature. It is seen, therefore, that at the early date in which Leonardo da Vinci lived, works of engineering were entrusted to men who under normal conditions had little or no connection with the armies. However, most works of early times were executed as adjuncts to military necessity, whereas engineering construction of the present time is undertaken to satisfy the requirements of public health and commerce.

For a great many years there have been two classes of men engaged in engineering, and although the character of the work done by these two groups is practically identical in many cases, yet because of their dissimilar organizations and responsibilities they are classified as military and civil engineers.

As the industrial world became more complex the great branch of civil engineering was divided into the four principal parts now known as civil, mechanical, mining and electrical engineering. Mechanical engineering was the first offspring of civil engineering and as mining become more important and as more efficient methods of mining became necessary, another branch was separated from the civil engineering group and became known as mining engineering. With the advent of electricity many mechanical engineers further specialized and classed themselves under the head of electrical engineers. And more recently two other branches based on chemistry and metallurgy, respectively, have entered the field.

The differentiation has gone still further than just indicated for what is now known as civil engineering is oftentimes divided into several minor groups such as structural, sanitary, municipal and railroad engineering, and subdivisions are also recognized in the mechanical and mining fields.

The following partial list of undertakings which the engineer is called upon to perform shows the main classes of work done by the four principal divisions, though it should be remembered that there are no well-defined lines of demarkation between them.

Civil engineering as now understood includes all kinds of surveying from the simplest land surveying to the complicated geodetic work where large areas or long boundary lines are involved; the design and construction of bridges and important buildings; extensive and difficult foundations and masonry structures of all kinds including retaining walls and dams; river and harbor works such as piers and jetties; highways; water supplies; sewerage; water-power plants; testing of materials of construction; and the construction and operation of systems of transportation including canals, steam and electric railroads.

Mechanical engineering embraces the design and construction of steam, gas and gasoline engines; locomotives; steamboats; automobiles; machine tools; hoisting and conveying machinery; pumps; turbines; elevators; heating and ventilat-

ing systems; various forms of machinery for manufacturing purposes.

Mining engineering includes shaft sinking and all underground mining work; drainage and ventilation of mines; transporting systems for removing mine products; reduction of ores; disposal and utilization of mine wastes; the location and operation of mines.

Electrical engineering deals with the generation, distribution and utilization of electrical energy and hence includes design, construction and operation of lines of communication; electric lighting plants; electrical portion of railways; signal systems; electric features of hydro-electric plants; all forms of electrical machinery such as dynamos, motors, switchboards and batteries.

The Inspiration of Engineering.

Engineering now affords greater opportunities for success than ever before, and for the many young men entering the profession each year there are plenty of chances to show ability and to reap the benefits of industry. Never before in the world's history have there been problems of greater magnitude and importance than await solution at the present time. Opportunities exist in abundance for reducing great economic and material wastes and for developing the great natural resources which surround us, and it is upon engineers that the responsibility for the successful solution of these problems will largely fall. The importance of this statement is realized when one considers that the combined estimated cost of the three largest engineering works now building is $559,000,000.

Most of the young men who join the profession are willing to spend four years of time, and, what to many of them are large sums of money, for training in our technical schools and colleges. Others, for lack of resources or for other reasons, enter the ranks directly without the preliminary training. By whatever path they find their way into the great profession of engineering, they should realize that it is only

by diligence, perseverance and a high-minded regard for its traditions and its ethics that they can ultimately occupy positions of responsibility and trust. Every young man who enters the engineering profession should do so because of his love for the work and because he is better fitted for it than for any other calling. No doubt a few go to the technical schools with the idea that upon the completion of their courses they can secure immediate financial return for their services, whereas, as graduates of medical or law schools they must spend considerable time after graduation in building up practice. The number of these, however, is very small. Most young men enter the engineering courses of our technical schools and colleges because they are determined to be engineers, and it is my experience that it takes a great deal to change the average young man's mind regarding this point. It is his determination to do a share of the great constructive work being done by the men who are following this noble calling that guides him into this field. To attain the greatest degree of success, the engineer must be loyal to the principles of his profession. He must support the ideals for which it stands and it is only by having high ideals himself that he can do this. Furthermore, the engineer should have clearly in mind the advantages of his profession, which can be briefly stated to be not only a fair remuneration, but what is of greater importance, the *satisfaction of seeing one's ideas crystallized in material form.* Remuneration for engineering work is generally thought to be not large but the average engineer's income from his own efforts is probably larger than the average of other similar callings. And there are many prizes to be won in positions of great trust and responsibility which carry very handsome incomes. However, the principal reason why engineering attracts many men is in the satisfaction with which the engineer contemplates his finished work.

It is the artist's satisfaction of crystallizing ideas into tangible forms that lures and holds the great engineer. He conceives the structure; rather vaguely at first, perhaps, but as his imagination continues to play, the idea assumes more

definite form till the general conception, together with those details which affect the general design, are completely thought out. The conception of the structure is then a product of the imagination, and hence it is that the young engineer should develop his imaginative powers; should train himself to see in his mind's eye that which is yet to have material existence. It must not be supposed that this faculty is to be used solely for the creation of engineering works. For although in their creation this power is essential yet the imagination must reach out to higher things. It must enable the engineer to see the good which others will receive as the result of his efforts, and thus it is that he subordinates self to the welfare and happiness of others. It is difficult to make young men realize what an important power imagination is in the design of engineering works. When the students of our technical schools are put through a course, such as descriptive geometry, which is planned to improve the power of imagination, they frequently fail not only to grasp the subject itself but to realize the purpose for which the course is given. Recently an architect while passing through a drawing room of a leading technical school where a class in descriptive geometry was being held, remarked that more time and attention than is common should be given to that subject. It was the realization of the great value of training the imaginative faculty that prompted this architect's shrewd and appreciative remark.

When the engineer has fixed the image of the structure upon his mind he finds it necessary to convey the thought to others, and this he does to some extent by verbal expression but chiefly by communications in the form of plans. A drawing is one of the simplest and most effective methods of conveying thought. Persons not familiar with the preparation and use of plans frequently find it difficult or even impossible to realize their value. But to the engineer the plan is a clear representation of his idea, a model which marks one step in the great work he is carrying on.

As the structure is building the engineer devotes his energies to securing the best results possible, and as piece after piece

is placed in position he begins to feel that success is assured. When the difficulties in the construction have been surmounted and the work is finished, then comes the satisfaction of having something to show for the effort. Not only for a day but for years it stands as a monument to the ability and the soul of him who conceived it, and he may look upon it with a feeling of having done something that will serve and help his fellow man. This is the point of view that should be urged upon the hundreds of young men who in class rooms and laboratories are now preparing themselves to take their places in the world's work.

Engineering Education.

Strength and quality are not necessary adjuncts of great numbers, but a membership of 6,326 in the American Society of Civil Engineers and a greater annual increase last year than ever before are certainly indicative of healthful conditions in the profession. During the last seven years the Society's membership has increased 100 per cent. This growth has been accompanied by a large increase in the number of civil engineering courses and graduates. Of the 2,182 alumni of Lehigh University practically one third are from the civil engineering department, and since January 1, 1905, the graduates of this department have increased from 470 to 714. These figures are here given to show that the department in question constitutes an important section of the University. Evidently the education which is given to young men under our guidance is a very serious matter, and its aims, ideals and accomplishments, should always be uppermost in our minds. Any system of education not based on a well-defined purpose cannot give the best results, and the courses in technology have in general been successful because they are established upon this fundamental principle. The writer believes that every teacher of engineering should keep constantly in mind two important ideas:

First, that the result mostly desired is to make useful citizens of the young men who enter the portals of the college; in

other words, to take men out of themselves and let them realize their responsibilities to other men and to their Maker. To do this it is not necessary to turn boys into old men, but it is necessary to show them that when they have a duty to perform, its successful performance is the most important thing in the world to them. Whether at work or play, their actions should be so honorable and their enthusiasm so contagious that the beholder cannot help but say "There is a man."

Let every college student realize that it is important not only to learn how to think but how to accomplish things as well, for the world gauges a man not only by what he knows, but by what he does and the manner in which he does it. The real purpose of teaching is not so much to show the student a large collection of facts but to guide him in such a manner that he will familiarize himself with the fundamental processes of reasoning. I say to guide him. This does not mean to show him. *The* thing is self-help; regarding which Herbert Spencer says in his "Intellectual Education," "Mark further the importance of the moral culture which this constant self-help involves. Courage in attacking difficulties, patient concentration of attention, perseverance through failures—these are characteristics which after-life specially requires; and these are characteristics which this system of making the mind work for its food specially produces."

To be the most useful citizen one must have a host of friends and therefore the student should be trained to understand and to deal with his fellow-students and the teaching corps and to make as many friends as possible in both these bodies. If this quality of mixing with men be acquired early in life it will not only render college days more pleasant and more profitable, but it will result in a breadth of view about men and things which will make a more useful citizen in after-life. Our system of education will be ideal when it produces the character which makes friendships such as that which causes Antonio to say:

"I pray you good Bassanio, let me know it;
And if it stand, as you yourself still do,
Within the eye of honor, be assur'd,
My purse, my person, my extremest means,
Lie all unlocked to your occasions."

Bearing in mind the citizenship ideal let not the engineering school lose sight of the fact that its second duty is to do its best to produce capable engineers; men who, having the creative instinct, need be given only the principles of the natural sciences to design, construct and operate the work of engineering. Courses in technology must not be made too narrow; not too broad. It is so easy to confuse breadth with superficiality when discussing college curricula. It is so easy for a teacher of engineering to deceive himself into thinking he is teaching engineering when he is in reality teaching the simplest practical details of construction which can be better and more quickly learned in shop or field. There is too much of this in technical courses and it is the constant aim at Lehigh to eliminate this evil; to give only the irreducible minimum absolutely necessary to enable students to understand and apply the principles of science to engineering design and construction. On the other hand let us not blind ourselves to the fact that some instruction masquerading under the guise of culture is of no cultural or practical value whatever when given to students whose social and educational environments are such that they cannot assimilate the culture and hence derive no benefit from the instruction. Let not the idea here be misunderstood. The value of culture is not questioned in the least; merely the attempt to give it to boys who are not in need of it and who cannot appreciate it. What subjects in a curriculum have cultural value? It is a wise man that can answer this when so much depends on the teacher. Physics, psychology, Greek, the theory of structures, may or may not have this quality.

The civil engineering course should be as broad as is consistent with thoroughness, and of such breadth as not to confine activities of its graduates to narrow limits. It should be

so administered that students will constantly have before them five things which they will diligently strive to obtain:

A desire to search out the truths of nature's laws.
The ability to think logically.
Initiative.
The power of analyzing and solving new problems.
Requisite perseverance to get things done right.

HENRY WILSON SPANGLER,

1858-1912.

Professor H. W. Spangler, a charter member of this society, a member of its Council (1893–4), and a Vice-President (1898–9), died at his home in Philadelphia of heart disease on March 17th. For the past three years he had been in ill health having but partially recovered from an almost fatal attack of the above ailment in the late summer of 1909. Professor Spangler's achievements as engineer, educator and administrator are known to the members of this society. The estimate in which he was held by his colleagues at the University of Pennsylvania are well summed up in the following tribute prepared by Professor Edgar Marburg and adopted at a special commemorative meeting of the faculty held on March 19th.

In recording the death, on March 17, of their friend and associate, Henry Wilson Spangler, Whitney Professor of Dynamical Engineering, the members of the University Faculty feel moved to give expression, however inadequately, to the great loss that has come to the University in the departure of one of her most efficient and devoted servants, and to their profound sense of personal bereavement in the death of a staunch friend and wise counsellor.

With the exception of a three-year period of service in the United States Navy, Professor Spangler has been a member of the Faculty of the University since 1881. For more than a quarter of a century he has labored for the advancement of the important interests committed to his trust, with a singleness of purpose and a self-sacrificing devotion that served as an inspiration to his associates, from the humblest to the highest. Endowed with quick initiative, resourcefulness, courage, and self reliance, his qualities of leadership stood out at their best at

times of emergencies; such as the destruction by fire of the old Mechanical Engineering Building, and the almost immediate and orderly resumption of activities in an incomplete, new building, with such facilities as could be quickly improvised. A strict and almost military disciplinarian, he was no less rigid in the standards which he applied to himself. The respect and admiration in which he was held by his students ripened into affection as they came to see him at closer range, and recognized the bigness of heart and the warmth of friendship that lay, poorly concealed, by a certain mantle of austerity. There were few graduates who failed to turn to him at some time for helpful counsel in the perplexities of later years, or who failed to accept it, even though it ran counter to their own promptings. They had implicit confidence in his judgment, and knew that his advice sprang from genuine, almost paternal, solicitude for their welfare, and that it was never given lightly. For some years before his death, he published, at his own expense, and sent monthly to every graduate of his department, a little pamphlet called the "Connecting Rod," designed to give them information about the department and about each other, in a simple, unaffected way. Everything he did, for that matter, was done in a like manner, for none had a more wholesome contempt for the vanities, affectations, or shallow pretenses of man.

He possessed to a remarkable degree the faculty of perceiving clearly, and almost intuitively, the essential elements of a seemingly difficult problem or complex situation, and he was as quick in action as in perception. Few excelled him in the clear discernment of the fallacies of an argument or in the directness of the challenge of such fallacies. Of a thoroughly progressive bent, he did not allow himself to be beguiled into strange paths by the educational fads and follies of the hour. The business of education was, to him, a serious business, with which liberties were not to be taken lightly. Although his talents were frequently brought into requisition in outer circles, his duties as a teacher, were, to him, ever of paramount importance, on which he allowed no professional obligations of a busy lifetime to trench unduly.

His University friends find it hard indeed to realize that his commanding figure has been seen upon the campus for the last time, and that in their councils his voice is stilled forever. None know better than they the sterling worth, the far-reaching significance of his performances in the services of the University, and especially of the Department for which he had planned and labored with such whole-hearted devotion, and on which he has left the enduring impress of his rare powers.

COLLEGE NEWS.

Armour Institute of Technology.—The development in the art of illumination in recent years has called for increased attention to this subject in colleges giving engineering courses. In order to increase its facilities for experimental and educational work in this line, the Department of Electrical Engineering at Armour Institute of Technology has recently equipped its principal lecture room with three different systems of illumination. These are the indirect, the semi-indirect, and direct systems. To provide for these three systems, five fixtures were installed containing a total of twelve lamps. One fixture, containing four lamps and reflectors, was hung from the center of the ceiling and is designed for the indirect system, though it is possible to change the reflectors so that direct or semi-direct lighting may be secured. The other fixtures were hung at the middle points of straight lines joining the center of the ceiling with the four corners. Each fixture is provided with two lamps and two reflectors, one reflector being directed vertically upward and the other vertically downward. The fixtures were designed to facilitate the changing of reflectors so that almost any desired type or form may be used. It is thus possible to secure indirect or semi-indirect illumination from the lamps in the four reflectors directed upward and direct illumination from the four directed downward. The wiring and switches are so arranged that only one circuit supplying four lamps can be in service at once. Special arrangements have also been made for inserting instruments to measure the current and voltage. The windows of the room are provided with opaque shades so that experimental work may be carried on during daylight hours.

Colorado School of Mines.—The senior class has recently been given addresses by prominent professional men of Den-

ver. Frank E. Shepard, president of the Denver Engineering Works Co., spoke on Modern Mill Practice and on Modern Mill Plant Design. John C. Traylor, of the Traylor Engineering Works, spoke on Jigging, and W. H. Trask, consulting engineer for the Central Colorado Power Co., spoke on Modern Hoisting Installations.

University of Illinois.—Mr. Francis S. Peabody, President of the Peabody Coal Co., of Chicago, on February 27 addressed the students and faculty of the College of Engineering on "The Operation of Coal Mines from a Commercial Standpoint."—About 40 students of the University, pursuing courses in railway engineering or railway administration have recently formed the Railway Club of the University of Illinois for the purpose of holding informal discussions on railway topics, and of promoting good fellowship.—Professor J. G. D. Mack, the exchange lecturer from the University of Wisconsin, on February 29 delivered two lectures before the students and faculty of the College of Engineering; one on the engineering features of the Wisconsin Tax and Public Utilities Commission, and the other on the engineering of ancient times and its value to the present-day engineer.

Massachusetts Institute of Technology.—Since the close of last year there have been several important changes in the faculty. Professor Gaetano Lanza has retired after forty years of efficient service, with the title of professor emeritus, and has formed a connection with the Baldwin Locomotive Works; he is succeeded in the department by Professor E. F. Miller as its acting head. Professor F. W. Chandler has also retired from the head of the architectural department where he has been for twenty-three years, and is now spending some time abroad. Professor Peter Schwamb, of the mechanical engineering department has also resigned; both Professors Chandler and Schwamb retiring with Carnegie pensions. Near the close of last year Mrs. Ellen H. Richards died after a distinguished service in the work of chemistry of thirty-four years.—In May, 1911, the Massachusetts Institute of Tech-

nology was able to secure from the state of Massachusetts a grant of $100,000 a year for ten years. Previous grants had been $25,000 a year for five years. Closely following this came a donation from T. Coleman du Pont, an alumnus, of $500,000 to go towards the purchase of a new site. At about the same time the will of Mrs. Rogers showed a bequest of nearly $500,000 without restrictions as to use. Within a very short time it became known that Francis C. Greene had bequeathed an estate estimated at $600,000 for the assistance of poor and meritorious students. Finally, on March 13, announcement was made of a gift of $2,500,000 for the erection of buildings necessary for purely educational purposes on the new site, the donor preferring not to have his name known.—The site selected for the "New Technology" is a tract of land of about fifty acres facing on the new Charles River Basin with a frontage of 1760 feet, a site without an equal around Boston for the placing of the Institute buildings.—Within about ten months the Massachusetts Institute of Technology is in receipt of new funds amounting to upwards of $5,000,000.

University of Minnesota.—Dr. H. T. Eddy, head of the department of mathematics, some time ago inaugurated the plan of having each professor in the department teach in rotation, from year to year, sections of the various classes in mathematics and mechanics, including hydraulics, etc. The professors are thus kept in touch with the requirements of the department and in closer sympathy with the students. They also avoid getting into ruts and so becoming mere machines instead of real, virile teachers.—For many years Dr. Eddy has personally conducted a class of graduate students, mostly teachers of physics and mathematics. He takes up with them the bearing of mathematics upon their several fields of work. Among the works studied have been such books as Drude's "The Theory of Optics," Webster's "Electricity and Magnetism" and Steinmetz's "Alternating Current Phenomena" and "Transient Electric Phenomena," Föppl and Abraham's "Theorie der Electricität," Love's "Electricity," Ibbetson's

"Elastic Solids." As would be expected, these studies have produced a beneficial reaction upon the instruction given by the members of the class especially in the two departments mentioned.—On March 1 the home of the College of Dentistry was destroyed by fire with a loss of $90,000. Fortunately the College of Engineering was able to house the classes of the College of Dentistry in the new experimental engineering building and instruction was resumed on March 11.—Frederick H. Bass, professor of municipal and sanitary engineering, was recently elected a member of the council of the engineering section of the American Health Association. In a report which he presented relative to the annual meeting of the American Society of Heating and Ventilating Engineers he states, "The meeting was one of the most important ever held by the Society. For the first time ventilation was largely discussed from a physiological as well as from a mechanical standpoint. It was the consensus of opinion that although ventilating systems might be provided which would furnish any given amount of air it was at present not at all certain what the most desirable elements in such air were. The precise differences between indoor and outdoor air as they are now known seemed to be inexplicable and it was the general belief that an extensive and thorough series of experiments would be very welcome. Entirely new methods are needed. The problem of ventilation is today recognized by sanitary engineers as one of the most important confronting them.

The Pennsylvania State College.—The department of civil engineering of the Pennsylvania State College is working in conjunction with the Pennsylvania State Highway department on an investigation of the effect of earth covering on culverts, and the effect of live loads on earth covered culverts. The college work is being done under the supervision of Professor Harold B. Shattuck.—The success that attended the good roads train sent out in the spring of 1911 over the Pennsylvania lines under the direction of the School of Engineering has led to the formation of a course in highway engineer-

ing. This course, which began in January, has aroused unusual interest. Up to the second semester of the junior year the course is identical with that in civil engineering; students taking the former then drop railroad engineering and substitute highway engineering for the remainder of the junior year, and through the senior year. The laboratory is equipped for testing all varieties of road materials. For field work the college possesses a log drag, road scraper, and a heavy steam road roller. Experimental roads will be constructed in the college grounds, and in the vicinity of the College, one such stretch of road about a mile in length having already been built.—On February 2, 1912, Mr. George E. Hulse, chief engineer of the Safety Car Heating and Lighting Co., lectured to the engineering students on the thermo jet system of car heating, and followed this with a lecture on the Safety Car Lighting system. On March 18 Mr. Calvin Rice, secretary of the American Society of Mechanical Engineers, addressed them on "The Relation of the Engineer to the National Engineering Societies." Mr. C. L. McIlvaine, assistant engineer of motive power, Pennsylvania Railroad, recently lectured on "The Trend of Modern Locomotive Development," and Mr. A. D. Cloud, editor of *The Signal Engineer,* will lecture on "Signalling, and the Signal Engineer," sometime during May.

NOTES ON PHYSICS TEACHING.

BY W. S. FRANKLIN AND BARRY MacNUTT,
South Bethlehem, Pa.

Second Paper.

After putting together our first batch of notes on the teaching of physics we intended to stop, but our first batch has affected us as we had hoped it would affect others, it has created in us the desire to discuss the subject further.

A Selection of Materials Necessary.

A selection of materials is necessary in the teaching of elementary physics, and the basis of selection should have reference to the point of view of inexperienced and untrained young men. We believe that the best selection (for the general student and for the engineering student) is to eliminate everything not familiarly known to young men or not likely to be of importance in an ordinary career.

If the chief object of physics teaching is to develop rational insights it is *sufficient* to consider familiar and practical things, indeed it is *necessary*, in the early stages of physics teaching, at least, because the profound sense of reality which everyone entertains with regard to familiar and practical things is the most effective check upon meaningless theorizing. Only an extremely vague sense of reality at best can be given to unfamiliar things in the class-room, and the study of unfamiliar things in an elementary course is an illusion.

Nearly everyone seems to think that the things which are detached from common experience are medicine for culture. Whereas, the things in physics which are detached from experience cannot possibly be assimilated by the student except by rote; and instead of being a medicine for culture these things are a drug producing stupidity! There is more than half a truth in John Perry's statement that we brand as

stupid those young men who are too honest to pretend by rote to understand mere abstractions.

Systematic Units.

We give a minimum of attention to C.G.S. units in our teaching because we have come to believe that the problem of introducing the metric system into the United States is not the problem with which a teacher of elementary physics is chiefly concerned, *and because we are convinced that the simplification of physical formulas by the use of systematic units is largely an illusion.* An altogether exaggerated estimate has been made of the increased facility of physical calculation by the use of systematic units. In fact calculations have not been facilitated by the introduction of systematic units, because the adoption of systematic units has resulted in their being merely added to units already in use. To calculate an unbalanced force by the formula $F = kma$ is exactly as easy and as rational as to calculate an unbalanced force by the formula $F = ma$. In fact the first formula is the more rational and the easier to understand because the presence of the factor k, *which is the force required to produce unit acceleration of unit mass,* emphasizes the importance of this fundamental quantity, whereas young men seem to lose sight of this fundamental quantity in the use of the simpler equation, the simplicity of which is indeed illusory.

The Eruption of π's in Electromagnetic Theory.

The choice of units in the "electromagnetic" system is no doubt not the best choice that could be made. Any improvement that might now be made, however, would be non-essential and of little consequence. *The time has come in the development of physical science to stop questioning established units,* until some new fundamental discovery opens the question in a manner to involve essential considerations.

One occasionally hears nowadays an expression of impatient contempt for π as it appears in electromagnetic theory, the

underlying idea being that our electrical units should be arranged so as to eliminate this hateful number. Now a great many people are inclined to laugh at the Indiana Legislature on account of a proposed legislation concerning the rôle of π in ordinary mensuration. Indeed the idea is not entirely absurd, because you can rule π out of the formula for the area of a circle, as every user of the circular mil knows; and yet but little is gained when this is done, because π then erupts, as Heaviside puts it, in the formula for the area of a square! So it is in electromagnetism, you can choose a system of units to eliminate π from any particular electromagnetic equation, but it always erupts somewhere else. What's the use trying to get rid of such a slippery number? But might we not ask the Carnegie Institution to appoint a learned commission to consider with the help of the Indiana Legislature the frequency of occurrence of π in every possible system of mensuration, geometrical, mechanical, and electrical, and adopt that system in which the frequency is a minimum?

Dimensional Formulas.

Any discussion of dimensional formulas is, in our opinion, not only useless but actually misleading. To have defined the average acceleration of a body during a given interval of time as the increment of the velocity of the body divided by the time (with due consideration of direction), and then ceremoniously to point out that acceleration is **A** length divided by the square of **A** time; and to set down the formula in "square brackets with capital letters" to emphasize the idea that the length under consideration is not a measured length and that the time under consideration is not a measured time, that neither the length nor the time have value but only denomination, and to imply that neither the length nor the time under consideration refer to any particular body [indeed how can such diaphanous quantities (?) refer to anything?]—all of this is an example of the very worst there is in physics teaching; and there is a great deal that is bad!

To address a boy directly with the proposition that Mr. So-and-So's income is a dollar a minute and to ask him on the basis of this proposition how long it will take for him (the boy) to save enough money to buy an automobile is to raise a laugh, but a teacher is safe in conveying the impression that a physical quantity refers to nothing in particular! Our one really great difficulty is to get students to keep actual things in mind when giving definitions. To define acceleration as **A** gain of velocity divided by **A** time is non-sense. To define the average acceleration of a given body during a given interval of time as the increment of the body's velocity during the time divided by the time is sense!

The Mechanical Equivalent of Heat.

We insist that the term mechanical equivalent of heat is archaic. Every one should understand that heat can be measured in joules and that the specific heat of water can be expressed in joules per degree. It would be as reasonable to speak of the ratio of the meter to the yard as the "English equivalent of French measurement" as to speak of the ratio of the calorie to the joule as the "mechanical equivalent of heat." There is nothing exactly wrong in either expression, but both expressions are vague in the extreme, and both carry suggestions which are entirely foreign to the matters under discussion.

Electricity and Magnetism from the Business End.

In our teaching of electricity and magnetism we always begin with electrolysis, taking up resistance and electromotive force, ferromagnetism, electromagnetism, induced electromotive force, and inductance, in order; and we take up electrostatics by considering the flow of the electric current through unclosed circuits and on the basis of the ballistic galvanometer.

The wide familiarity of young men with the phenomena of the electric current and the fact that most of the practical

applications of electricity have nothing to do with electrostatics convince us that this order of development is pedagogically sound. Anyone who imagines it to be less logical than the traditional order is unduly under the influence of his thought-habits, for, in fact, one order is exactly as logical as the other.

We depart, however, from the strictly logical development in that we are content to use the legal definition of the ampere in the earlier stages of our work, believing that a young man need not be demoralized by standing for a short time on the only foundation that would be tenable in an appeal to the Supreme Court of the United States as to the meaning of an ampere!

Ohm's Law Gone to Seed.

The generalizations of physics so far transcend the experience of an individual that there is a kind of danger in dealing with them day after day as a mere teacher; a highly developed and sound critical faculty with reference to the impersonal ideas of physics is rare and the ideas tend to become so distorted as to be no longer applicable. What physics teachers need most to cultivate is a predilection for homeliness; without an uncompromizing passion for homeliness even experimental research cannot fortify a teacher against the perverting tendency of pedagogy.

The usual statement of Ohm's law is an example of a generalization gone to seed. One teacher states that "this law holds for all *constant* currents or currents whose strength changes very little in course of time" and another guards his statement of Ohm's law by adding "as long as the physical state of the conductor remains the same." Now Joule found the amount of heat generated in a metallic conductor to be proportional to the square of the current and to the time ($=RI^2t$), and from the definition of electromotive force the amount of work delivered to a circuit is equal to EIt. Therefore, *if all the work delivered to a circuit is dissipated in the*

circuit in accordance with Joule's law, then $RI^2t = EIt$, or $I = E/R$. Ohm's law is therefore true when all the work delivered to a circuit is dissipated in accordance with Joule's law; Ohm's law is not true when magnetic work, or chemical work, or mechanical work is done by the current, nor when the dissipation of work as heat does not conform to Joule's law, as in gaseous conductors and so-called insulators.

Another Example.

"The effect of a force is the same whether the force acts alone or in conjunction with another force." Such is the statement, by one teacher, of Newton's second law of motion. He does not even make it plain that he is referring to the accelerating effect. Now the principle of superposition in physics, or, to put it more elegantly, the existence of additive effects in physics depends fundamentally upon a simple proportional relationship between cause and effect, and to postulate the proportional relationship is usually the simplest and most direct form in which to state the principle. There is, therefore, no justification for the above statement of Newton's second law even if the author had stated explicitly what kind of effect he referred to. Every boy knows that the effects of forces on thin ice are NOT additive; but we have never yet found the young man who would state the proposition in this elegant way!

Potential.

The electric potential at a point is the "height" at that point of an imagined "hill" whose "slope" is everywhere equal to the electric field intensity.

Some electric field distributions can be looked upon as slopes or gradients, and such electric field distributions have potential.

Some electric field distributions cannot be looked upon as slopes or gradients, and such electric field distributions do not have potential.

How many users of the word potential understand that the word as universally used in electromagnetic theory refers to an electric field distribution in precisely the manner above stated? *How many users of the word appreciate that its utility is absolutely zero except where one wishes to think* VERY PARTICULARLY *about the actual distribution of an electric field in space?* And how many users of the word understand what kind of electric field distributions have potential and what kind have not?

If the terminology of elementary physics is to be kept in accord with the more advanced phases of the science, the word potential and the word potential-difference must be used with due regard to the matter above mentioned, and the widely prevalent misuse of the two words potential-difference and electromotive force to mark the distinction between the internal electromotive force of a voltaic cell and the electromotive force between the terminals of the cell must absolutely cease.

It is of the utmost importance to use those quantities which have direct connection with physical conditions and things. Thus everyone realizes the importance of such ideas as the temperature at a point, the temperature gradient at a point, the pressure at a point in a fluid, the energy density at a point in an electric field, the velocity of a fluid at a point, the intensity of an electric field at a point, and so on. And we believe with Heaviside that even the correct use of the word potential tends to turn one's attention away from physical things. Everyone, and especially those whose ideas are mere thought-habits, will admit the fictitious character of the velocity potential of a fluid, namely, an imagined "hill" whose slope is everywhere equal to the fluid velocity; but with electrical potential it is different, the word (we say the word because very few indeed use the idea) has become an obsession. The magic word energy appears in one of the legitimate definitions of potential and that settles the matter! Energy, "the only real thing in the universe" as one teacher exclaims! Let us cease talking energy and talk sense, and above all let

us keep clear of such blunders as to say "Electric potential may be defined as *the condition at a point in space* which determines the direction in which an electrified body placed at that point would tend to move."

The Use of Lecture Demonstrations.

Two years ago, after the most careful instruction in elementary mechanics we gave the following "original" problem at the final examination of a group of Freshman engineering students:

"A cart moves due northwards at a velocity of 11 feet per second. A man pushes downwards on the cart with a force of 200 pounds and a mule pulls northwards on the cart with a force of 50 pounds. At what rate does the man do work and at what rate does the mule do work?"

Forty-four per cent. of the men found that the man developed 4 horse-power and the mule 1 horse-power! If mention had been made of the part of his body the man used in exerting the force of 200 pounds, every man in the class would have caught the idea!

Physical ideas do not take shape in young men's minds when they read the most carefully arranged written statements, and consequently young men have little native ability to understand impersonal and non-anthropomorphic writing. Nothing, perhaps, in the realm of elementary science training is more important than to develop this kind of ability which depends upon the possessions of ideas. *The most important function of lecture demonstrations is to bring ideas and things together, and the best physics lecturer is one who can, as it were, pull ideas out of things like a prestidigitateur!* This kind of a prestidigitateur needs only a few very simple things, the simpler the better. To use lecture demonstrations to create a world of unfamiliar phenomena is a grave mistake, and to allow a physics lecture to degrade to vaudeville is contemptible.

The Inversion Involved in Formal Laboratory Work.

When laboratory work is carried out on the basis of a laboratory manual, the student nearly always does the actual work, and studies it out afterwards when he writes up his report, whereas most complicated things in this world have to be thought out before they are done, or while they are being done. To do a laboratory exercise as per recipé is to convert laboratory work into an inconsequential kind of cookery. And to think out a laboratory exercise after it is completed is as uninteresting, as to ponder upon cookery after a splendid collation!

The reality of physical thinking lies very largely in the intelligent performance of physical operations, and the value of laboratory work depends almost wholly upon this fact. Our newly established laboratory method, which is briefly described in our first paper, is satisfactory chiefly because it has enabled us to eliminate the ridiculous inversion above mentioned.

Our Point of View.

We have tried to keep away from generalities in the preparation of these notes, and yet, in looking them over, we realize that many of our statements come out of very general considerations. It could not perhaps be otherwise, but the many more or less good-natured expressions of amused contempt which some of our "prefaces" and "introductions" have called forth seem to show that our point of view is very different from that of most of our fellow teachers. Few readers, however, seem to appreciate what is the greatest resource of writers who poke fun at those who take the half-made things in science too seriously, the resource, namely, which is afforded by highfalutin language. Indeed there is a form in literature which is expressive of the climax of contempt, of the spit-in-the-face, namely the alliterative form; and yet most readers are so thick-skinned that they sense only a writer's pomposity therein! What *are* poor writers to do?

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